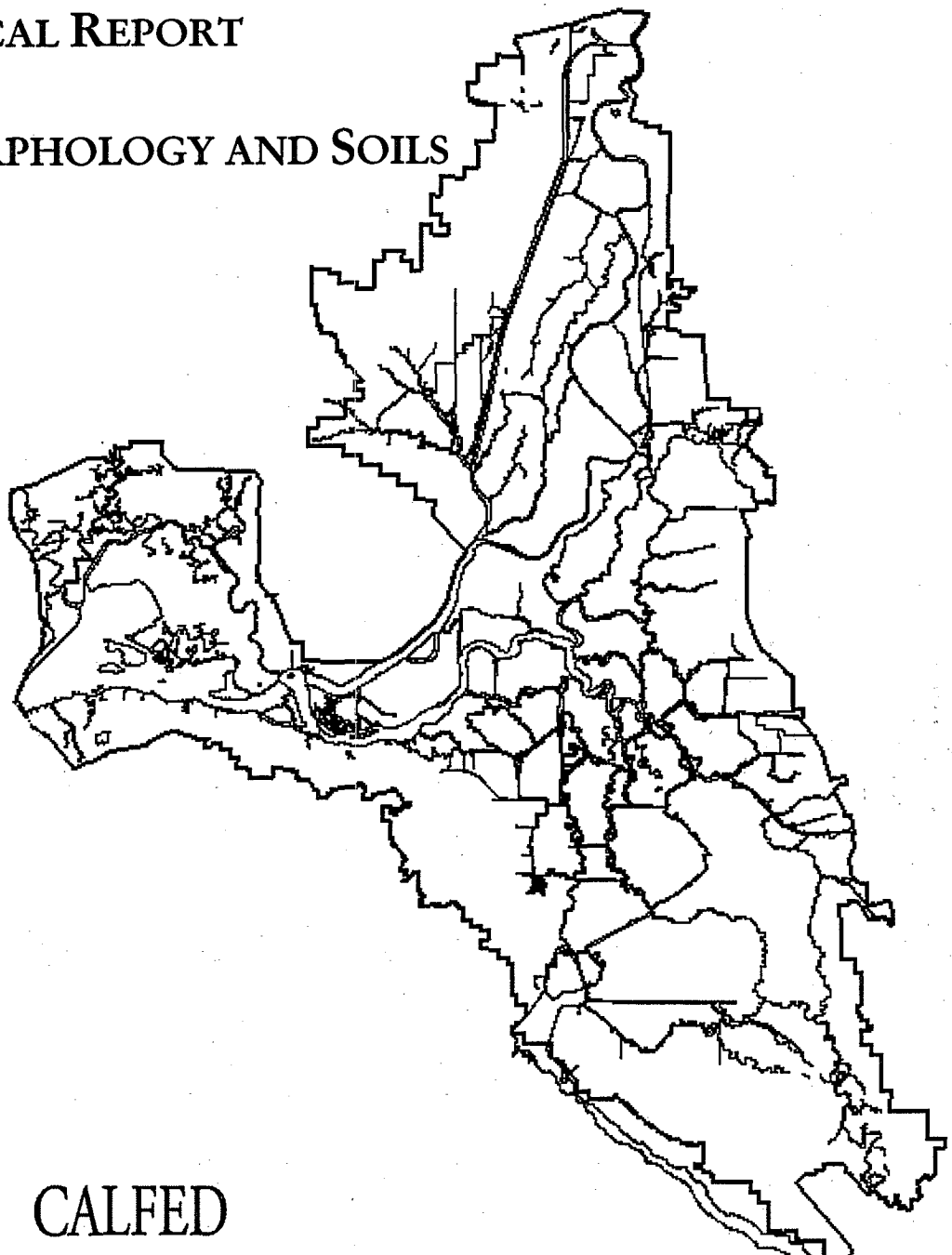
CALFED BAY-DELTA PROGRAM

DRAFT IMPACTS/CONSEQUENCES TECHNICAL REPORT

GEOMORPHOLOGY AND SOILS



CALFED
BAY-DELTA
PROGRAM

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ENVIRONMENTAL IMPACTS
Geomorphology and Soils
Technical Report
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1.0 INTRODUCTION

The intent of the CALFED Bay-Delta Program (Program) is to develop long-term solutions to problems affecting the San Francisco Bay/Sacramento-San Joaquin Delta estuary in Northern California. Overall, the effect of the Program is expected to be beneficial. However, specific Program components may have potentially adverse impacts.

The purpose of this technical report is to document, in a programmatic manner, the potential impacts of the Program on geomorphology and soils that could result from the no action alternative or implementing any of the three Program alternatives. This report discusses potential impacts that may occur in the five regions within the study area including the Delta region, Bay region, Sacramento River region, San Joaquin River region, and the SWP and CVP service areas. The report also contains a brief description of potential mitigation strategies designed to reduce Program impacts to a less than significant level. The executive summary contained in this technical report in will be used conjunction with other information, data, and modeling developed during pre-feasibility to prepare the environmental impacts section of the Programmatic EIR/EIS.

Section 2.0 describes a summary of overall effects in order to highlight geomorphologic and soils impacts described in the analysis to follow. Assessment methods and significance criteria are presented in Sections 3.0 and 4.0, respectively, to describe the variables, methods, and criteria used to assess the significance of a given geomorphologic or soils impact. Finally, Section 5.0 compares the effects by region of the three CALFED alternatives on geomorphology and soils in the study area.

2.0 EXECUTIVE SUMMARY

This section summarizes the potential significant impacts and unavoidable significant impacts on the geomorphologic and soils resources in the study area, and strategies to mitigate these impacts.

2.1 SUMMARY OF POTENTIAL SIGNIFICANT IMPACTS

2.1.1 Alternative 1

Each of the three configurations (1A, 1B, and 1C) proposed under Alternative 1 would result in both potential beneficial and adverse geomorphology and soils impacts. These impacts include direct and construction related effects, as well as indirect and operational effects. Table 1, Summary Comparison of Impacts, in

Section 5.4, lists the impacts of each sub-alternative. The following is a summary.

Beneficial impacts would include:

- reduced levee soil erosion in the Delta due to in-channel islands;
- beneficial reuse of dredged material;
- reduced soil depletion and erosion as a result of habitat restoration activities;
- reduced release of pollutants under the water quality actions, resulting in a potential reduction in sediment contamination;
- reduced subsidence in the Delta Region through shallow flooding of islands;
- reduced erosion in enlarged channels.

Potentially adverse impacts would include:

- the conversion of existing agricultural soils for new uses, such as habitat restoration, levee system construction, storage facilities, or conveyance improvements;
- increased erosion due to ground disturbance for surface water storage and conveyance facility construction in the Sacramento and San Joaquin River regions;
- increased channel bottom scour in the Delta Region due to reoperation actions;
- sediment trapping in new on-stream reservoirs.

Potential, indirect geomorphologic and soils impacts associated with future changes in water availability would be expected to be minimal, and insignificant.

Alternative 1 is not expected to have a significant effect on geomorphology and soils in the Bay region, or in SWP and CVP service areas outside of the Central Valley.

2.1.2 Alternative 2

Each of the five configurations (2A, 2B, 2C, 2D, and 2E) proposed under Alternative 2 would result in both potential beneficial and adverse geomorphology and soils impacts. These impacts include direct and construction related effects, as well as indirect and operational effects.

Potential beneficial and adverse impacts would include those described previously under Alternative 1. In addition, the in-Delta storage in Alternative 2C would result in a potential adverse impact due to the conversion of agricultural soils for storage. Table 1, Summary Comparison of Impacts, in Section 5.4, summarizes the impacts of each sub-alternative.

Potential, indirect geomorphology and soils impacts associated with foreseeable changes in water availability would be expected to be minimal, and insignificant.

Alternative 2 would not be anticipated to have a significant effect on geomorphology and soils in the Bay region, or in SWP and CVP service areas outside the Central Valley.

2.1.3 Alternative 3

Each of the nine configurations (3A, 3B, 3C, 3D, 3E, 3F, 3G, 3H, and 3I) proposed under Alternative 3 would result in potential beneficial and adverse impacts to geomorphology and soils. These impacts include direct and construction related effects, as well as indirect and operational effects. These potential beneficial and

adverse impacts are described under Alternative 1. Table 1, Summary Comparison of Impacts in Section 5.4 lists the impacts of each sub-alternative.

Potential, indirect geomorphology and soils impacts associated with future changes in water availability would be expected to be minimal, and insignificant.

Alternative 3 would not be anticipated to have a significant effect on geomorphology and soils in the Bay region, or in SWP and CVP service areas outside the Central Valley.

2.2 SUMMARY OF MITIGATION STRATEGIES

The following measure shall be implemented to mitigate potentially significant geomorphology and soils impacts identified for Alternatives 1, 2, and 3:

- protecting exposed soils with mulches or geotextiles and vegetative ground covers to prevent erosion;
- implementing bank stabilization projects;
- encouraging sediment in some channels to mitigate for lost soils;

2.3 SUMMARY OF POTENTIAL SIGNIFICANT UNAVOIDABLE IMPACTS

Significant unavoidable impacts of the project alternative could include:

- losses of agricultural soils;
- land subsidence in the Delta and Central Valley. Land surfaces could be monitored to determine if an area is undergoing subsidence.

3.0 ASSESSMENT METHODS

CALFED actions could have direct effects on specific environmental variables which affect geomorphology and soils such as flows, erosion, water quality, turbidity, substrate, etc. These environmental variables would in turn impact the soils and substrates by changing rates of erosion, sedimentation, or water availability, by directly creating new vegetative communities, or by removing or converting existing communities.

Projections of changes in quality and quantity are measures used to determine potential impacts of the alternatives being considered. Where enough detail is available to determine the size and/or location of a specific alternative feature, the impacts can be measured in terms of direct losses or conversion of soil types, or changes to the environmental conditions that influence them. When this level of detail is not available, an estimate of losses, changes, or types of changes that might be expected to occur is made.

In addition to direct impacts to soil conditions and geomorphology, changes in their respective attribute quality may occur. For example, changing water availability may not result in changes in the areal extent of plant communities but may result in changes in growth patterns or seed production that would affect the quality of the future plant communities and co-dependent soils. Projection of such impacts would be very general due to the uncertainties involved.

Geomorphology and soil quality depend on the characteristics of the soils (e.g.,

erodibility, organic content), management or use of the soil (e.g., agricultural and irrigation practices), and compositions and condition of underlying materials and aquifers. CALFED actions could affect soil conditions, subsidence, and seismic hazards through actions that affect the quantity of and quality of irrigation water applied to soils, changes to the amount of land under irrigation, improvements to Delta levees, relocation of infrastructure in the Delta, and changes to agricultural practices, groundwater management and vegetative communities.

The types and quantities of hydrologic and hydrodynamic data that are made available from model simulations will determine the overall approach taken to the assessment of erosion and sedimentation impacts within Delta, river and estuary channels, open water areas, sloughs, meanders, and side channels. At the programmatic level it will probably be general, with the detailed analyses deferred to the Phase III project level EIR/EISs.

Changes in the volumes and timing of instream flows resulting from changes in the quantities and timing of water storage could produce changes in the velocities that occur in channels and along shorelines and levees. Increased velocities will produce increased erosion whereas decreased velocities will generally cause increased deposition of materials, or sedimentation. Impacts will be complex and variable and will depend on the fluvial geomorphologic changes induced which will vary in response to many factors, including season. In some cases the changes will be beneficial; in others, detrimental. Outcomes will vary depending on the channel geometry, type of substrate, mitigation measures such as armoring, bank and levee slopes, and the amounts and types of vegetation present.

Altered reservoir release and flow patterns can also change salinity gradients in the estuarine portion of the system as well as temperatures and water densities. These changes, especially changes in salinity, may cause significant impacts to the locations and rates of settling, deposition of suspended sediments and bedload, erosion, and resultant sedimentation. More dramatic changes will result from the construction of reservoirs, such as conversion of perennial or intermittently-flowing streams to water impoundments.

Land use assessment encompasses analysis of soil changes that result directly from construction of new facilities or conversion of lands from one use to another, and analysis of indirect effects of changes in policies, resources, or economies. The assessment of effects of soils changes on soils and geomorphology will address both the direct and indirect consequences of program actions.

Although a programmatic assessment will not provide site-specific details for areas of direct effect, potential changes in the areas of given land uses by region will be estimated. The response of landowners and managers to changes in water supply conditions, economic conditions, and land and water management policies can result in changes in land uses between agricultural, open space/habitat, and developed uses and consequent changes in soil characteristics.

Potential CALFED actions such as the construction of water-related facilities, changes in water operations, habitat restoration, improvements to levee systems,

and changes in land management (e.g., agricultural practices) also could have direct and indirect effects on geomorphologic and soil conditions in the various regions of the study area. Construction impacts to soils and substrates may be extensive and profound, depending on the location, structure and construction type, season, and extent and degree of mitigation.

Construction of water-related facilities could convert agricultural soils, recreational or open space lands, and terrestrial or aquatic biological habitats to developed structures, infrastructure, or open water habitat. CALFED actions, such as improving water quality and water supply reliability, could indirectly affect soils by creating opportunities for municipal and industrial development or changes in agricultural uses. Construction of water facilities (e.g., reservoirs) could create other indirect soils effects. Economic growth stimulated by CALFED actions also could result in indirect changes in soils as a result of altered land uses (e.g. quantity and type of agriculture, open space/habitat, and urban development). All of these changes could produce direct or indirect changes to underlying soils and geomorphologic features by altering surficial contours and substrates, altering chemical and physical processes, and/or altering the amount of water or humidity present.

In all cases, mitigation measures will be applied to reduce adverse impacts to the fullest extent possible.

3.1 IMPACT MEASURES

Two types of analysis have been included: changes in areal extent due to direct loss, conversion, or creation of soil types and geomorphologic conditions; and changes in their quality. Changes to the areal extent of soil types and geomorphologic resources and conditions have been defined and analyzed by using various tools that focus primarily on spatial analyses. The projected changes in acreages of each soil type and geomorphologic condition are used as the primary quantitative measures of impacts. Secondly, an increase or decrease in the degree of access to an area occupied by high value soil series has been used to indicate whether beneficial uses of the soil resources will be beneficially or adversely affected.

The assessment of qualitative impacts considers geographic extent, distribution, quality, and spatial configurations. A project that affects the continuity of a linear riparian plant community or drainage patterns in wetlands, for example, may have greater impact on soils than changes in areal extent. The severity of impacts is determined by the magnitude of changes in the quality or condition of the soils and surface geomorphology.

Impacts on the quality of soils utilized for agricultural soils were determined from existing literature, including published agricultural economic sources, and information from appropriate agencies (e.g., California Department of Conservation, California Department of Food and Agriculture, County Agricultural Commissioner's Offices, and the University of California Extension). The impacts to each soil series would be determined by the change in acreages and values. Impacts to the areal extent or quality of agricultural soils were caused by two types of activity: conversion to other plant communities as part of a habitat-related restoration action or

direct loss from construction of project features.

As a Programmatic EIS/EIR, this assessment will not provide site-specific details nor estimates of acreages potentially affected for a given alternative. Rather, potential increases or decreases in the area of a given soils by region will be qualitatively estimated. Among the five regions discussed in this report, it is assumed that the level of detail provided for analysis of the Delta region will necessarily be greater than that for the other four regions. The reason for this divergence is twofold: 1) the vast majority of physical improvements contemplated by the various alternatives would be implemented in the Delta region, rather than in the other regions; and 2) a substantially greater number of applicable soils and environmental studies are available for the Delta region than for the other regions.

3.2 ASSESSMENT VARIABLES

The programmatic geomorphology and soils assessment will evaluate potential changes to the following resource categories and assessment variables. Supporting variables that can potentially influence the resource categories follow each category:

Surface soil erosion

- Agricultural soil loss due to area cultivated and agricultural practices
- Irrigation
- Wind erosion
- Stormwater sheet, rill and gully erosion

Channel, basin, shore and shallows erosion and sedimentation

- Velocities and flows
- Channel and cross sectional configurations
- Longitudinal variations, slopes and energy gradients
- Channel roughness (Manning's n)
- Bank protection and vegetation
- Channel islands
- Sediment loads
- Salinity gradient, location and temporal variability

Soil salinity

- Soil geology
- Applied water quality (E.C. or TDS)
- Agricultural drainage

Soil drainage characteristics

- Soil percolation rates

Subsidence caused by the overburden mass loading and oxidation of organic content

- Levee mass overburden
- Dam and reservoir overburdens
- Fill mass overburden (island interiors)
- Organic soil content (especially peat)
- Soil moisture
- Ground disturbance and tilling practices

Subsidence caused by groundwater withdrawals

- Groundwater surface elevations
- Groundwater withdrawals
- Aquifer clay content

Geomorphology and soils impacts due to soils changes

- Acres in agricultural use;
- Acres in open space and habitat uses;

- Acres in developed uses.

Assessment variables that will determine soils acreages and characteristics follow:

Agricultural Use

- Net loss of water deliveries to agricultural contractors resulting in net loss to cropland
- Potential irrigation of lands outside existing or proposed place of use (additional acres)
- Potential irrigation in Class 6 or unclassified lands (additional acres)
- Impact any lands classified as prime and unique farmlands
- Decrease in water quality (increased salinity) for agriculture
- Unmaintained water levels during the irrigation season
- Loss of use of agricultural soils for one growing season
- Planting orchards or vineyards, building structures, or constructing permanent improvements within the rights-of-way of pipelines
- Agricultural land uses that become susceptible to flooding
- Alterations to agricultural activities
- Crop substitution effects on agricultural activities
- Direct and cumulative conversion of agricultural soils

Open Space and Habitat Use/Developed Use

- Potential conversion of wetlands due to agricultural or urban development (additional acres)
- Irrigation or urban development on lands outside existing place of use
- Land acquisition and relocation
- Displacement of property owners
- Displacement of residences and structures on reservoir islands
- Conversion of wetlands and upland habitats for levee construction or modification
- Conversion of recreational facilities to other developed uses

3.3 ASSESSMENT METHODS

Surface soil erosion is a function of soil types and their relative erodibility, wind and water erosivity, slope and slope length, vegetation cover, and soils and management. Soil erosion is an area of concern in agricultural production.

Soil salinity is the result of salt accumulation over time in surface soils. Soil salinity is affected by the salinity of applied water, the amount of excess irrigation water applied to flush the salts, and the salinity and level of the groundwater. Soil salinity is of particular concern in the San Joaquin Valley and the southeastern areas of the Delta (near Stockton).

Oxidation of organic soils in the Delta has resulted in land subsidence. Factors affecting subsidence in the Delta include the organic content of the surface soil, soil moisture and water table management, seasonal flooding, and ground disturbance and tilling practices. Outside the Delta, land subsidence can be caused by increasing groundwater withdrawals. When an aquifer is dewatered, clay materials within the aquifer consolidate, causing the land surface above to subside. After an area has subsided, irreversible changes to the aquifer occur. Subsidence resulting from groundwater withdrawals is influenced by the groundwater levels in the aquifer, rates

of recharge versus withdrawal for the aquifer, and the geology and mineralogy of the aquifer.

There is a risk that Delta island levees could fail due to active seismicity, and although there have been no catastrophic failures attributable to seismic events, significant damage has occurred in the form of cracks and sloughing of banks. The susceptibility of levees to failure from seismic activity (ground shaking and liquefaction) is affected by levee materials, foundation, and height. The likelihood of a seismic event would not change from existing conditions, but the relative susceptibility of Delta resources and infrastructure to seismic events could be influenced by plans for improvements to levees, projected changes in the rate of subsidence, and changes in island management and soils influenced by CALFED actions.

Assessment methods compare differences in the rates of soil erosion, soil salinity, and subsidence among CALFED alternatives. In addition, construction-related soil erosion rates under the CALFED alternatives are compared based on the expected area of disturbance, regional location, duration, kind of construction disturbance, and average erodibility of soils in the region.

Changes in region-wide erosion rates are derived from changes in soils and management. Estimates of changes in soil erosion are qualitative or semiquantitative because of variability in soil type, soil erodibility, slope, and land management throughout the region. County soil surveys and discussions with district conservationists of the Natural Resources Conservation Service (NRCS) are used as the basis for projections of soil conditions and soils practices.

Soil salinity problems are assessed based on the projected area of salt-affected soils. In the Delta area, soil salinity is dependent on the quality of water withdrawn from the Delta channels. When available, results of Delta water quality models simulations may be used to assess where salinity in Delta channels will increase or decrease, and comparisons may be made of land areas affected by changes in the quality of intake water. For the San Joaquin Valley and other water export areas affected by soil salinity because of high groundwater, differences in soil salinity problems areas are estimated based on differences in the electrical conductivity (EC) of export water, the resultant requirements for excess irrigation water to flush salts, and expected effects on the groundwater levels. Plans for agricultural tailwater drains are also factored in. In addition, the effect of using groundwater and project water as alternative sources is assessed. The soil salinity assessment, performed on a county-by-county basis, will incorporate the advice of NRCS District conservationists.

Differences in subsidence from peat oxidation in the Delta are described in terms of the area of drained peat soils and the rate of subsidence of drained areas. For example, CALFED actions that could affect subsidence include using Delta islands for water storage or wetland habitat and improving the land on which levees are built through in-Delta conveyance using setback levees.

Assessing subsidence resulting from groundwater withdrawals is based on

projected rates of subsidence by groundwater basins or irrigation districts, changes in the amounts or reliability of delivered water, and resulting changes in the rate of groundwater pumping.

Other assessment areas also provide inputs to the soil assessment. Projections of soils from the impact assessments for soils and agricultural economics provide input to the assessment of erosion and subsidence. The evaluation of salinity (EC) in Delta irrigation water and export water from water quality assessments provides data for the assessment of soil salinity impacts. Output from the evaluation of soil erosion provides information for the air quality analysis (dust and particulate matter evaluations), and information from the geology, soils, and seismicity assessment is used in the flood control evaluation of the Delta.

Hydraulic and hydrodynamic modeling can be undertaken using models ranging from simple HEC 1 and 2 models, to more complex one dimensional hydrodynamic models such as DWRDSM 1 and 2 for the Delta, to sophisticated two and even three dimensional models that are being developed for the estuary from Chipps Island and Suisun Bay downstream. These models can produce the needed changes in flows, stages and velocities, and even water quality, but sediment modeling will ultimately be needed to build off those results. Sediment models are less well developed so it is likely that the degree of confidence in the results will be lower. Alternatively, empirical models, calculations, and geomorphologic engineering judgment may be applied to determine expected effects on a case by case, location by location basis; or again very general results may be used, pending development of the details of CALFED alternative projects and the requisite models.

Soil conversion impacts will be evaluated through comparison between conditions under the CALFED alternatives and point-of-reference conditions. Direct impacts of the CALFED alternatives on land uses are estimated through comparison of the generalized spatial distribution of land uses in the program area to areas potentially converted to specific uses (e.g., facilities and habitat restoration) and estimation of the amount of existing land being converted to other uses.

Assessment of indirect impacts to geomorphology and soils resulting from changes in soils or flows relies on related analyses conducted in this Programmatic EIR/EIS. Changes in open space/habitat acreage and conditions are addressed in the wetlands and terrestrial habitat analysis. Where applicable, information from the regional economics and demographics assessment is used to determine relative differences in land uses that result from population and economic growth in those areas affected by changes in water deliveries.

3.4 RELATIONSHIP TO OTHER ASSESSMENT METHODS OR TOPICS

As described above, the geomorphology and soils impact assessment variables are closely related to other resource assessments and methods, including those for soils, terrestrial, channel and wetland habitats, water use, water supply and operations, and recreation. Additionally, results of the geomorphology and soils assessment will support analysis of impacts on storage and conveyance, riverine

hydraulics, system integrity, biological resources, visual aesthetics, cultural resources, flood control, surface water conditions, soils, water quality, and air quality.

4.0 SIGNIFICANCE CRITERIA

As part of a Programmatic EIR/EIS, this section must address the significance criteria recommended in the *State CEQA Guidelines*, considering whether changes in geomorphology and soils that could result from implementation of program alternatives would: (a) conflict with existing land uses; (b) adversely affect agricultural resources or operations (e.g., degrade farmlands or impede agricultural practices, or impacts from incompatible land uses); © conflict with applicable environmental plans or policies adopted by jurisdictional agencies; (d) induce conflicts with general plan designations or zoning; (e) degrade biological resources; or (f) disrupt or divide the physical arrangement of any established community.

4.1 DEFINITION

The primary reason for establishing significance criteria is to satisfy the CEQA requirement to determine the thresholds at which impact magnitudes constitute significant impacts. The CEQA statutes and guidelines define a "significant effect on the environment" in Chapter 2.5, Section 21068, as a substantial, or potentially substantial, adverse change in the environment (Governor's Office of Planning and Research 1995). The guidelines (Section 15382) define "significant effect on the environment" as "a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance." However, neither CEQA nor the CEQA guidelines establish mandatory thresholds or levels at which an adverse impact is considered significant. Appendix G of CEQA provides a list of actions that might "normally have a significant effect on the environment," but use of these criteria is not mandatory, and CEQA thus allows the lead agency discretion in the selection, use, and application of significance criteria that are appropriate for the setting and circumstances of each project.

The National Environmental Policy Act (NEPA) does not have the same mandatory finding of significance as does CEQA, but NEPA does discuss how significance of impacts can be defined in terms of context and intensity (Section 1508.27). In considering context, the action must be analyzed under several contexts such as society as a whole, the affected region, any notable interest and issues, and the locality. Consideration of context means that the setting of the proposed action should be taken into account. Intensity refers to the severity of the impact.

The advantage of establishing thresholds of significance for the CALFED Bay-Delta Program and subsequent projects is the consistency and predictability provided to the environmental impact analysis of alternatives and their components. Significance criteria are applied at both the Programmatic EIR/EIS level as well as the later project-specific EIR/EISs. Given the breadth and complexity of the Bay-Delta Program, and the fact that it will be implemented over an extended time period, establishing and

documenting significance criteria at the programmatic stage will provide a basis from which later environmental impact analysis can be drawn.

4.2 DETERMINING IMPACT SIGNIFICANCE THRESHOLDS

The significance of an activity varies depending on the environmental setting in which the activity occurs. Thresholds of significance for a given impact may include flexible standards that recognize differences in the environmental setting. Thresholds may also be qualitative or quantitative.

The general nature of the planning and the broad range of settings and impacts involved with the Phase II Bay-Delta Program dictate the use of qualitative thresholds of significance at this programmatic stage. The thresholds can and will be made more definitive and more quantitative at the project-specific level.

The methodology used to develop proposed thresholds for geomorphologic and soil resources include the following considerations:

Thresholds Should be Qualitative

Because the Phase II CALFED Bay-Delta Program document is programmatic, quantitative data are limited. Therefore, thresholds are phrased in qualitative terms indicating potential changes from either baseline (existing or historical) conditions or future conditions under the No Action Alternative. These comparisons provide indications of the potential for significant impacts for use in the Programmatic EIR/EIS. These qualitative and general thresholds provide the basis for the establishment of more specific or qualitative thresholds in the project-specific Phase III EIR/EISs. At the time when specific actions are identified, thresholds may be expressed in quantitative terms based on site-specific data and existing or baseline conditions.

Thresholds Should be Applicable to Anticipated Actions and the Study Area

Each threshold needs to address the actions and components as identified for the No Action Alternative and Alternatives I-III within the overall study area identified for the programmatic document.

Consolidation of Thresholds

An attempt was made to consolidate threshold subjects (e.g., single or multiple locations, or facilities) as much as possible, keeping in mind the fact that the programmatic document will need to address broad categories of impacts in the Bay-Delta and larger areas at only a general level of detail.

Thresholds Apply only to Adverse Impacts

As stated in Section 15382 of the CEQA Guidelines "significant effect on the environment" means a substantial, or potentially adverse change in any of the physical conditions.

Proposed Significance Threshold Criteria

1. Removal, filling, grading, or disturbance of soils; especially those that support wetlands and riparian communities, special-status species habitats or communities, or ESA-designated critical habitat areas.

2. Substantial degradation of the quantity or quality of native soil types or their environmental and water quality protection characteristics in significant watersheds tributary to the Sacramento and/or San Joaquin Rivers.

3. Substantial disruption of soils that support vegetation or forage species of importance to wildlife, recreation, agriculture, parklands, or ecologically or economically important fish species.

4. Releases of toxic materials from soils or sediments.

5. Alterations to, or drainage from, soils or substrates that create conditions that increase the potential for outbreaks of wildlife diseases.

6. Adverse changes in rates of sedimentation and erosion.

7. Adverse changes in soil drainage or salinity.

8. Soil subsidence and increases in subsidence rates that produce adverse effects (e.g. soil losses, reductions in groundwater basin storage capacity, soil compaction, and levee collapse).

9. Changes in soil conditions that cause undesirable seepage to adjacent lands.

10. Increased potential for soil erosion by wind, waves and currents.

11. Oxidation of, or drainage; from peat soils when this causes adverse effects.

12. Increased potential for erosion and mass failure - induced landslides.

13. Increased potential for seismic activity or vulnerability of soil - comprised structures to seismic events.

14. Disruption of natural or favorable soil profiles and horizons.

15. Increased potential for damage from geological hazards.

16. Impacts upon any soils on lands classified as prime and unique farmlands.

17. Water level changes which would adversely impact soils utilized for agriculture.

18. Impacts to geomorphology and soils resulting from changes in soils or flows to wildlife refuges.

5.0 ENVIRONMENTAL IMPACTS/CONSEQUENCES

This section describes the impacts associated with the no action and proposed alternatives on the geomorphology and soils resources in the Delta, Bay, Sacramento River, and San Joaquin River regions.

5.1 IMPACTS OF NO ACTION ALTERNATIVE BY REGION COMPARED TO EXISTING CONDITIONS

The geomorphologic and soils conditions under the no action alternative would be very similar to the existing conditions described in the affected environment. CVP and SWP operations would remain similar to existing conditions with increased demands on the system. Channel geometry in the Delta, Bay,

Sacramento River, and San Joaquin River regions would not be altered by other than current, ongoing, geomorphologic or dredging processes.

The following sections describe the expected conditions in the Delta, Sacramento River, and San Joaquin River regions relative to existing conditions.

5.1.1 Delta Region

The no action alternative could result in significant impacts to some geomorphologic and soils resource areas in the Delta region, including soil salinity, soil surface erosion and subsidence, and seismic susceptibility of levees to failure.

5.1.1.1 Soil Salinity

Soil salinity problems would be expected to continue in the south and west Delta regions. The south Delta salinity problems are tied to relatively low flows and high salt concentrations in the San Joaquin River inflow. Under the no action alternative, farmers could be restricted to growing salt tolerant crops, since salinity conditions would not change. Elevated levels of soil salinity could worsen in the south and west Delta due to the seepage and the poor quality of applied water caused by ocean salinity intrusion and increasing high total dissolved solids concentrations from increasing amounts of land-derived agricultural drainage.

5.1.1.2 Erosion and Subsidence

Under the no action alternative, the island interior soils would continue to undergo peat oxidation, continuing the soils susceptibility to wind induced erosion, and contributing to further levee instability. Erosion of submerged levee slopes and channels would continue to be an issue.

5.1.1.3 Soil Selenium

High Selenium concentrations could intensify in the channels and applied irrigation water in the south Delta from land-derived San Joaquin Valley agricultural drainage.

5.1.1.4 Seismicity

Some Delta levees would continue to be susceptible to seismic failure, as they have sandy sections with relatively low density. Seismic failure of the levees would result in a potentially significant impact to the Delta channels' morphology and soils on the island interiors.

5.1.2 Bay Region

The no action alternative is not expected to result in any changes in to geomorphologic or soils conditions in the Bay region relative to existing conditions.

5.1.3 Sacramento River Region

In the Sacramento River region, the issue of concern is primarily land subsidence. Land subsidence has historically occurred in the southern portion of the valley. Long term declines in groundwater levels in this region could result in additional subsidence.

5.1.4 San Joaquin River Region

In the San Joaquin River region, the issue of concern is primarily land subsidence. Land subsidence has

historically occurred on the western side of the valley, as well as the southwestern portion of Tulare County and the southern end of Kern County. Long term declines in groundwater levels in this region could result in additional subsidence.

5.1.5 SWP and CVP Service areas Outside Central Valley

No changes to geomorphology and soils are expected to occur in this region as a result of no action.

5.2 IMPACTS OF CALFED ALTERNATIVES BY REGION COMPARED TO EXISTING CONDITIONS

5.2.1 Delta Region

5.2.1.1a Alternative 1A

Ecosystem Restoration Program

Under the Ecosystem Restoration Program (ERPP), various sites would be improved throughout the Bay-Delta system for habitat restoration. In addition, the program would include development of floodways and meander zones, and installation of fish screens. Soils and geomorphologic conditions potentially affected by these improvements would be primarily on soils utilized for agriculture.

Im pact - Potentially Beneficial. *Reduced soil depletion and wind erosion on Delta islands due to habitat restoration.* Conversion of agricultural soils for habitat restoration under the ERPP could improve geomorphologic and soil conditions, since habitat restoration would return humus and nutrients to the soils, and protect them from depletion and erosion.

Impact - Potentially Beneficial. *Reduced levee soil erosion rate due to implementation of modified levee and berm management practices.* Under the ERPP, agreements with willing levee reclamation districts would promote establishment and maturation of shoreline riparian vegetation. Riparian vegetation could reduce water velocities adjacent to the levees, and thereby reduce soil erosion potential.

Impact - Potentially Beneficial. *Reduced wave-induced levee soil erosion due to creation of in-channel islands.* Protection and maintenance of in-channel islands would reduce wind-fetch, thereby reducing wave generated erosion on nearby levees.

Water Quality Program

Impact - Potentially Beneficial. *Reduction in release of pollutants resulting in a reduction in potential sediment contamination, including salinity and selenium.* The Water Quality Program focuses on source control and reducing the release of pollutants into the Bay-Delta system and its tributaries. Activities proposed for the Water Quality Program would not have an adverse effect on geomorphology and soils in the Delta region; instead the activities would remove potential sources of sediment contamination, including salts.

Water Use Efficiency Program

The Water Use Efficiency Program addresses the efficient use of developed water supplies, and is principally concerned with policy issues to be implemented by

local agencies. Activities proposed for the Water Use Efficiency Program would not have a direct effect on geomorphology and soils in the Delta region.

Levee System Integrity Program

The Levee System Integrity Program would be implemented in its entirety. Soils and geomorphologic conditions potentially affected by these improvements would be primarily on lands utilized for agriculture.

Impact - Potentially Adverse. *Conversion of agricultural soils for levee construction.* Conversion of agricultural soils for levee system construction would produce significant changes to geomorphology and soils in the affected areas. Agricultural soils would be covered where new setback levees are constructed. Soils on the channel side could be improved by habitat restoration and sediment deposition measures; however, the soils would also be subject to erosion during floods.
Mitigation Strategy. Exposed soils could be protected with mulches, geotextiles, and vegetative ground covers to the extent possible to prevent erosion. Bank stabilization projects could be implemented where needed. Sedimentation could be encouraged with vegetation in desired areas to mitigate for lost soils and provide a substrate for new habitat.

Impact - Potentially Beneficial. *Reduced subsidence through shallow flooding of central and western Delta lands.* The program would reduce subsidence rates through the creation of wetlands from shallowing flooding of 30,000 to 60,000 acres of land in the Delta.

Impact - Potentially Beneficial. *Reduced risk of increased salinity on Delta islands.* Incorporation of seismic retrofits could reduce the risk of catastrophic levee failure, thereby reducing the risk of salinity intrusion from the ocean, which could increase the salinity in the soils.

Impact - Potentially Beneficial. *Replacement of soils.* Beneficial reuse of dredged material could replace soils that would otherwise be lost.

Storage and Conveyance

Conveyance and storage facility improvements are not included in Alternative 1A.

Reoperation

Impact - Potentially Adverse. *Additional channel bottom scour and bank erosion.* Reoperation may cause flow velocities in some channels leading to the pumps to increase slightly, and this could cause additional channel bottom scour and bank erosion.
Mitigation Strategy. Erosion and scour rates would not likely increase substantially, therefore any erosion would be gradual. Monitoring would identify areas of increased erosion and implementation of erosion control measures, such as vegetative covers, would reduce rates.

5.2.1.1b Alternative 1B

Ecosystem Restoration Program

The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included in Alternative 1B.

Conveyance

Impact - Potentially Adverse. *Conversion of agricultural soils for conveyance improvements.* Conveyance improvements would be comprised of south-Delta modifications and Central Valley Project-State Water Project (CVP-SWP) improvements. Principal soils impacted by conveyance modifications under Alternative 1B would be agricultural. Conversion of agricultural soils for conveyance improvements would be a significant soils impact of this alternative.

Impact - Potentially Adverse. *Short-term increases in erosion rates due to construction of conveyance improvements.* Construction of the conveyance improvements could cause disruption of soils in the vicinity of the project. The amount of disruption would depend on the construction methods used and construction site access requirements. Much of the construction would take place during the dry season, reducing precipitation-based erosion during this part of the season. However, during the wet season, erosion rates may increase if the disturbed soils have not recovered in time to accommodate the runoff.

Mitigation Strategy. Methods to reduce the soil erosion impacts could include grading of the site to avoid concentrations of overland flow, use of silt fences or hay bales to trap sediment, and revegetation following completion of construction.

Impact - Potentially Adverse. *Increased soil and channel erosion in some channels due to modifications allowing greater flow through the Delta and export at the pumps.* Greater capability to pump water out of the Delta could result in increased volumes of water in some channels, and potentially increased channel velocities, increasing the potential for erosion of levee soils.

Mitigation Strategy. Erosion of soils could be monitored and strategies implemented in areas with significant impact. Strategies could include protecting soils with mulches, geotextiles, and vegetative ground covers to the extent possible. Bank stabilization projects should be implemented where needed. Sedimentation could be encouraged with vegetation in desired areas to mitigate for lost soils.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.1c Alternative 1C

Ecosystem Restoration Program

The activities of this program under this alternative would be similar to those under Alternative 1A; however, some environmental water flows would be met through use of new storage specifically allocated to environmental water supplies. The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

Impact - Potentially Beneficial. *Reduced applied salt loads due to increased flows from additional storage facilities.* New ground and surface water storage would increase the amount of water available during the summer and fall months to dilute salinity in waters from tributaries with return flows that have potentially high concentrations. The additional flows in the summer and fall would also reduce salinity intrusion from the ocean and transport more dissolved salts to the ocean, thereby reducing applied salt loads.

Conveyance

Conveyance improvements would be similar to those for Alternative 1B, but would expand the range of south-Delta modifications and CVP-SWP facilities. The impacts of this program are described under Alternative 1B and below.

Impact - Potentially Beneficial. *Reduced levee soil and channel erosion rates due to south Delta modifications.* Enlargement of channels in the south Delta would reduce water velocities in those channels, reducing the potential for levee soil erosion. However, increased erosion potential identified under Alternative 1B could occur under this alternative in the north Delta, because these channels would not be widened.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.2a Alternative 2A

Ecosystem Restoration Program

Activities under this program would be similar to those described under Alternative 1A, with some differences in the habitat restoration areas within the Delta. The following impacts are in addition to those identified under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included in Alternative 2A.

Conveyance

Conveyance improvements would include a new screened intake at Hood, north-Delta channel modifications, south-Delta modifications, and CVP-SWP improvements. Geomorphologic features and soils potentially impacted by these components would be primarily agricultural with some urban modifications at Hood. Potential impacts of south-Delta modifications would affect agricultural soils. Potential impacts of conveyance improvements to the CVP-SWP facilities in the south-Delta would primarily affect agricultural channel-side geomorphology and soils. The impacts are described under Alternative 1B and below.

Impact - Potentially Beneficial. *Reduced potential for channel and levee soil erosion.* Construction of setback levees and the widened channels would reduce the potential for levee soil erosion. Creation of widened channels would increase the cross-section, thereby reducing velocities. Vegetation could protect the exposed portion of the levee from potential erosion.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.2b Alternative 2B

Ecosystem Restoration Program

The impacts of this program are described under Alternatives 1A and 2A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The impacts of this program are described under Alternative 1C.

Conveyance

The impacts of this program are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.2c Alternative 2C

Ecosystem Restoration Program

Impacts of this program are identified under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

Impact - Potentially Adverse. *Conversion of agricultural soils for water storage facilities.* New in-Delta water storage would potentially affect agricultural soils. Conversion of and loss of agricultural soils for water storage would be a significant impact of this alternative.

Conveyance

Conveyance improvements proposed under Alternative 2C include three south-Delta conveyance channels; various south-Delta modifications; and CVP-SWP improvements. Land forms and soils potentially impacted by conveyance components would be primarily agricultural. The impacts of this alternative are described under Alternative 1B, 2A, and below.

Impact - Potentially Beneficial. *Reduced erosion potential due to construction of south Delta intakes.* Construction of south Delta intakes could result in reduced erosion potential in some channels. The intakes would allow diversion of water from selected channels (e.g., Sacramento River), reducing the flows downstream of the intake, thereby potentially reducing velocities and erosion of levee soils in some downstream channels.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.2d Alternative 2D

Ecosystem Restoration Program

Existing land forms and soils potentially affected by the Ecosystem Restoration Program would be principally agricultural, with some low-density urban uses at Terminous. The impacts are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The impacts of this program are described under Alternative 1C.

Conveyance

Conveyance improvements for Alternative 2D would include: a new screened intake at Hood; modifications to the Mokelumne River Floodway and east Delta wetlands habitat; south Delta habitat modifications; and CVP-SWP improvements. Land forms and soils potentially impacted by conveyance improvements would be principally agriculture with some developed uses associated with Highway 12. The impacts of this alternative are described under Alternative 1B, 2A and 2C.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.2e Alternative 2E

Ecosystem Restoration Program

The impacts of this program are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is included under Alternative 2E, but not in the Delta region.

Conveyance

Conveyance improvements for Alternative 2E would include: modifications to sites such as Tyler Island, Mokelumne River Floodway, east-Delta wetlands habitat, south-Delta habitat, and CVP-SWP improvements. Land forms and soils potentially impacted by these components are agricultural. Modifications proposed under Alternative 2E for the Mokelumne River Floodway and east-Delta wetlands habitat would be similar to those proposed for Alternative 2D. South-Delta habitat modifications and associated impacts would be the same as Alternative 2C. The conveyance impacts are described under Alternative 1B, 2A and 2C.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3a Alternative 3A

Ecosystem Restoration Program

The impacts of this alternative are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The Levee System Integrity Program would be implemented in its entirety; however, the Program would be adjusted to accommodate new setback levees. Principal land forms and soils affected would be agricultural. The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included in this alternative.

Conveyance

Conveyance improvements would include north-Delta channel modifications, south-Delta modifications, CVP-SWP facilities, and an isolated facility. Land forms and soils potentially impacted by these components are principally agricultural, with some urban uses along the Interstate 5 corridor. The impacts of this alternative are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3b Alternative 3B

Ecosystem Restoration Program

Under Alternative 3B the Ecosystem Restoration Program would be implemented with modifications. The impacts of this alternative are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The in-Delta storage impacts are described under Alternative 2C. The impacts of storage facilities that would be located outside of the Delta Region are described under Alternative 1C.

Conveyance

The impacts of this program are described under Alternative 1B.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3c Alternative 3C

Ecosystem Restoration Program

The impacts of this alternative are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included in Alternative 3C.

Conveyance

Conveyance improvements proposed under Alternative 3C are the same as Alternative 3A, except for the components of the isolated facility. Land forms and soils potentially impacted by conveyance components would be agricultural. The impacts are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3d Alternative 3D

Ecosystem Restoration Program

The impacts of this alternative are described under Alternatives 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The in-Delta storage impacts are described under Alternative 2C. The impacts of storage facilities that would be located outside of the Delta Region are described under Alternative 1C.

Conveyance

The impacts of this program are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3e Alternative 3E

Ecosystem Restoration Program

The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The in-Delta storage impacts are described under Alternative 2C. The impacts of storage facilities that would be located outside of the Delta Region are described under Alternative 1C.

Conveyance

Conveyance improvements for Alternative 3E would include modifications in the south-Delta, and CVP-SWP improvements. Land forms and soils potentially impacted by these components are agricultural. The impacts of this program are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3f Alternative 3F

Ecosystem Restoration Program

The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The impacts of storage facilities outside of the Delta Region are described under Alternative 1C.

Conveyance

Conveyance improvements for Alternative 3F would include: new intake facilities; isolated island conveyance facilities; North and South Delta modifications; and CVP-SWP improvements. Land forms and soils potentially impacted by these components are agricultural. The impacts of this

program are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3g Alternative 3G

Ecosystem Restoration Program

The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The in-Delta storage impacts are described under Alternative 2C. The impacts of facilities outside of the Delta Region are described under Alternative 1C.

Conveyance

Conveyance improvements for Alternative 3G would include; north- and south-Delta modifications; CVP-SWP improvements; and an isolated facility. Land forms and soils potentially impacted by these components would be agricultural. The impacts of this program are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3h Alternative 3H

Ecosystem Restoration Program

The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Conveyance

Conveyance improvements for Alternative 3H would include: modifications to Tyler Island, Mokelumne River floodway, east-Delta wetlands habitat, and south-Delta habitat; CVP-SWP improvements; and an isolated facility. Land forms and soils potentially impacted by these components are agricultural. The impacts of this program are described under Alternative 1B and 2A.

Storage

The impacts of storage facilities outside of the Delta Region are described under Alternative 1C.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.1.3i Alternative 3I

Ecosystem Restoration Program

Alternative 3I would implement the entire Ecosystem Restoration Program, with modifications. The impacts of this program are described under Alternative 1A.

Water Quality Program

The impacts of this program are described under Alternative 1A.

Water Use Efficiency Program

The impacts of this program are described under Alternative 1A.

Levee System Integrity Program

The impacts of this program are described under Alternative 1A.

Storage

The in-Delta storage impacts are described under Alternative 2C. The impacts of facilities outside of the Delta Region are described under Alternative 1C.

Conveyance

Conveyance improvements for Alternative 3I would include: isolated south-Delta intakes; an isolated Sacramento River intake; south-Delta modifications; and CVP-SWP improvements. Land forms and soils potentially impacted by these components are agricultural. The impacts of in-Delta storage are described under Alternative 1B and 2A.

Reoperation

The impacts of this program are described under Alternative 1A.

5.2.2 Bay Region

5.2.2.1 Alternative 1

Alternative 1 could alter existing in-Delta land forms and soils in the immediate vicinity of the activity or facility; however, no significant effects on geomorphology and soils in the Bay region are expected. Implementation of Alternative 1 also could affect the availability of water resources in the Bay Area; however, potential geomorphologic and soils impacts associated with foreseeable changes in water availability are expected to be minimal, and insignificant. The only potential effect would be associated with changes in sediment transport out of the Delta and into the Bay. CALFED alternatives would likely cause only minor decreases in sediment transport from the Delta to the Bay.

No mitigation strategies are required for the Bay region, as no significant impacts were identified.

5.2.2.2 Alternative 2

The impacts of Alternative 2 on geomorphology and soils in the Bay region would be the same as those described under Alternative 1.

5.2.2.3 Alternative 3

The impacts of Alternative 2 on geomorphology and soils in the Bay region would be the same as those described under Alternative 1.

5.2.3 Sacramento River Region

5.2.3.1a Alternative 1A

Common Program

Direct and construction-related impacts of the four common programs (Ecosystem Restoration, Water Quality, Water Use Efficiency, and Levee System Integrity) could alter or displace soils in the immediate site vicinity of the activity, but is not expected to have a significant adverse effect on geomorphology and soils in the Sacramento River region as a whole.

Certain targets of the ERPP could affect the Sacramento River geomorphologic processes. These targets include:

- establishment of stream meander belts;
- gravel recruitment;
- reduced use of seasonal diversion dams.

Impact - Potentially Beneficial. *Reestablishment of riparian meander belts.* Actions to establish stream meander belts include purchase of riparian lands and restoration of floodplains through construction of setback levees. Establishment of meander belts would extend the range over which streams currently migrate, allowing the stream channels to erode and change over a greater path.

Impact - Potentially Beneficial. *Improved gravel recruitment and transport conditions in the Sacramento River and its tributaries.* Gravel recruitment actions would include stockpiling gravel at strategic locations to mimic the natural processes of the streams. This program would be monitored to determine the effects on channel erosion and meander processes.

Impact - Potentially Beneficial. *Increased sediment transport potential due to removal and/or reduction of the number of diversion structures on Sacramento River tributaries.* Removal of structures, or the reduction in structures would reduce any sediment trapping occurring on the affected tributaries, allowing more natural transport of sediment downstream. Depending on the tributary affected, these actions could increase the sediment supply downstream, resulting in sedimentation in the Sacramento River and Delta, and possibly increase dredging in some areas.

The Water Quality Program actions would also affect soils and geomorphology in the Sacramento River region.

Impact - Potentially Beneficial. *Watershed management measures would reduce soil erosion potential.* Watershed management practices, such as slope stabilization measures and vegetative cover would reduce protect the ground surface from water and wind induced erosion.

Storage

New water storage is not included in Alternative 1A.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

Reoperation of CVP-SWP facilities could result in increased flows during some months. These increased flows would have a greater capacity to transport sediment and erode channel banks than under existing conditions. While sediment transport and erosion is greatest during periods of greatest flow (e.g., during the winter and spring months), increased flows during the lower flow periods could alter the existing erosion/deposition processes. The magnitude of the change would likely not adversely impact soil erosion and sediment transport. However, some change could occur and is, therefore, identified.

Indirect Impacts

Implementation of Alternative 1A could affect the availability of water resources throughout the region. Potential secondary geomorphology and soils impacts include alterations caused by changes in the quantity of agricultural acreage, and the pace and location of urbanization. The extent of these changes would be minimal. Thus, indirect impacts associated with Alternative 1A would be insignificant.

5.2.3.1b Alternative 1B

Common Program

The impacts associated with this program are described under Alternative 1A.

Storage

No new water storage is proposed under Alternative 1B.

Conveyance

Conveyance improvements would be located in the Delta region, and would not have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.1c Alternative 1C

Common Program

The impacts associated with this program are described under Alternative 1A.

Storage

New water storage for Alternative 1C could include facilities in the Sacramento River region, and result in potential adverse impacts to the area.

Impact - Potentially Adverse. *Conversion of agricultural soils for storage in the Sacramento River region.* Conversion of agricultural soils for storage facilities would be a significant geomorphologic and soils impact of this alternative.

Impact - Potentially Adverse. *Potential short-term ground disturbance and increases in erosion rates in the vicinity in storage construction areas.* Construction of storage facilities would require ground disturbance. The extent of the ground disturbance would depend upon the site selected for a reservoir and the type of dam constructed. Concrete dams are generally less massive than earthfill dams, and would likely require less excavation of material to construct. Increased erosion rates could occur on areas cleared for storage facilities or access roads.

Mitigation Strategy. Methods to reduce the soil erosion impacts could include grading of the site to avoid concentrations of overland flow, use of silt fences or hay bales to trap sediment, and revegetation following completion of construction.

Impact - Potentially Adverse. *Sediment trapping in new reservoirs.* New reservoirs on streams could trap sediment, reducing the supply downstream. Reducing the sediment supply could alter the stream's erosion capability and geomorphologic characteristics. The reduction in sediment bedload would be greatest when flows are greatest.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.2a Alternative 2A

Common Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included under Alternative 2A.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.2b Alternative 2B

Common Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage for Alternative 2B could include facilities in the Sacramento River region. The impacts of new storage facilities are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.2c Alternative 2C

Common Program

The impacts of this program are described under Alternative 1A.

Storage

No new storage is proposed in the Sacramento River region under this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.2d Alternative 2D

Common Program

The impacts of this program are described under Alternative 1A.

Storage

No new storage is proposed in the Sacramento River region under this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on

geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.2e Alternative 2E

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3a Alternative 3A

Common Program

The impacts of this program are described under Alternative 1A.

Storage

New water storage is not included under Alternative 3A.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3b Alternative 3B

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3c Alternative 3C

Common Program

The impacts of this program are described under Alternative 1A.

Storage

No new water storage is included under this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3d Alternative 3D

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts associated with this alternative are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3e Alternative 3E

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3f Alternative 3F

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3g Alternative 3G

Common Program

The impacts of this program are described under Alternative 1A.

Storage

The impacts associated with this alternative would be similar to those described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3h Alternative 3H

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.3.3i Alternative 3I

Common Program

The impacts of this program are described under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the Sacramento River region.

Reoperation

The impacts of reoperation are described under Alternative 1A.

Indirect Impacts

The indirect impacts associated with this alternative are described under Alternative 1A.

5.2.4 San Joaquin River Region

5.2.4.1a Alternative 1A

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A. In addition, the following beneficial impact could result from the Water Use Efficiency Program:

Impact - Potentially Beneficial. *Reduced subsidence levels due to increased supply from conjunctive use practices.* Conjunctive use would involve the use of ground water in combination with surface water to for water supply. Water would be stored in

aquifers for use when surface water availability is lower. Conjunctive use of ground water basins could potentially reduce overdraft in some areas of the San Joaquin Valley, thereby reducing land subsidence.

Storage

New water storage is not included in Alternative 1A.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under San Joaquin river Region, Alternative 1A.

5.2.4.1b Alternative 1B

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage is not included in Alternative 1B.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin river region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.1c Alternative 1C

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage for Alternative 1C could include facilities in the San Joaquin River region. The impacts of new storage facilities are described under Alternative 1C.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.2a Alternative 2A

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage is not included in Alternative 2A.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.2b Alternative 2B

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage for Alternative 2B could include facilities in the San Joaquin River region. The impacts of storage facilities are described under Alternative 1C in the Sacramento River Region.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.2c Alternative 2C

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

No new storage is proposed in the San Joaquin River region under this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.2d Alternative 2D

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

The proposed 2.0 MAF of off-aqueduct storage under this alternative would be located off-stream. Impacts would include increased erosion and conversion of soils described under Alternative 1C in the Sacramento River Region.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.2e Alternative 2E

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3a Alternative 3A

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage is not included in this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3b Alternative 3B

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3c Alternative 3C

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

New water storage is not included in this alternative.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3d Alternative 3D

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3e Alternative 3E

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3f Alternative 3F

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3g Alternative 3G

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3h Alternative 3H

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.4.3i Alternative 3I

Common Program

The impacts of this program would be similar to those described for the Sacramento River region under Alternative 1A.

Storage

Storage impacts are described under Alternative 1C in the Sacramento River Region section.

Conveyance

Conveyance improvements would be located in the Delta region, and are not anticipated to have a significant effect on geomorphology and soils in the San Joaquin River region.

Reoperation

The impacts of reoperation would be similar to those described under Alternative 1A for the Sacramento River region.

Indirect Impacts

The indirect impacts associated with this alternative are described under Sacramento River Region, Alternative 1A.

5.2.5 SWP and CVP Service areas Outside of the Central Valley

None of the proposed alternatives (1, 2, or 3) are expected to affect existing land forms or soils in the SWP and CVP service areas outside of the Central Valley. Implementation of the alternatives could affect the availability of water resources throughout the service areas; however, secondary potential geomorphologic and soils impacts associated with foreseeable changes in water availability would be expected to be minimal, and insignificant.

No significant adverse environmental effects of the alternative on geomorphologic and soils were identified. Thus, no mitigation strategies are required.

No significant unavoidable impacts on geomorphology and soils are projected for this alternative.

5.3 IMPACTS OF CALFED ALTERNATIVES BY REGION COMPARED TO NO ACTION

The no action alternative would result in conditions very similar to the existing conditions, with some possible worsening of the soil salinity, subsidence, and levee stability conditions. The impact of the common programs and the storage and conveyance improvements relative to the no action alternative would be similar to the impact relative to existing conditions.

5.4 SUMMARY OF COMPARISONS BY REGION

The following tables summarize the impacts of the no action alternative with respect to existing conditions and the proposed alternatives as compared to both existing and no action conditions. Impacts are summarized for the Delta, Sacramento River, and San Joaquin River regions only. The Bay and CVP and SWP service areas outside of the Central Valley are not included because the proposed alternatives are not expected to affect these regions.

Table 1 - Summary of Potential Significant Impacts

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Delta Region					
Surface Soil Erosion	Widespread wind - induced erosion and loss of Delta soils occurs. Levee and surface soil erosion at sites of levee breaks is a serious problem.	Same as Existing with following impact potential modifications: Wind-induced erosion and loss of Delta soils would continue; over time, island surface elevations would decrease as a result. Levee soils and surface soils at sites of future levee breaks would continue or worsen.	Same as Existing with following additional impact potential modifications: **All** - Conversion of agricultural lands to wetlands would reduce wind erosion to extent that Alternative acreage is converted; soil losses would be reversed in those areas. **All** - In-channel islands would reduce wind fetch and lessen consequent wave-induced levee soil erosion. **All** - Beneficial re-use of dredged material can reduce or replace soils otherwise lost **1B.** Increased channel velocities could increase potential for levee soil erosion. **1C.** Channel enlargements in South Delta would reduce	Same as Alternative 1 with following additional impact potential modifications: **All** - Levee setbacks and island flooding would reduce potential for both levee and interior island soil erosion and losses. **All** - Widened channels and additional Clifton Court Forebay intake would reduce channel velocities and lessen levee soil erosion. **2C.** Channel velocities would be further reduced when two or three of the South Delta intakes are used, resulting in less levee soil erosion.	Same as Alternative 1 with following additional impact potential modifications: **All** - Use of an isolated facility would reduce in-Delta channel velocities and reduce potential for levee soil erosion. The larger the isolated facility, the greater the potential reduction. **3E.** Would have the greatest potential to reduce wind-induced soil erosion due to inundation, but the highest potential for interior island wave-induced levee soil erosion.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
			channel velocities and reduce potential for levee soil erosion.		
Channel Erosion and Sedimentation	Submerged levee slopes and sub-surface soil erosion in channels and at sites of levee breaks are serious problems.	Submerged levee slopes and sub-surface soil erosion in channels and at sites of levee breaks would cause serious and worsening problems.	Same as Existing with following additional impact potential modifications: **1B.** Increased channel velocities could increase potential for channel bank and bottom erosion and subsequent down-stream deposition. Additional scour and sedimentation could occur near the export pumps. **1C.** Channel enlargements in South Delta would reduce channel velocities and reduce potential for channel bank and bottom erosion and subsequent down-stream deposition. Additional scour and sedimentation could occur near the export pumps.	Same as Alt. 1 with following additional impact potential modifications: **All** - Increased channel velocities could increase potential for channel bank and bottom erosion and subsequent down-stream deposition. Additional scour and sedimentation could occur near the export pumps.	Same as Alt. 1 with following additional impact potential modifications: **All** - Decreased channel velocities could decrease potential for channel bank and bottom erosion and subsequent down-stream deposition. Decreased scour and sedimentation is likely near the export pumps however it could increase near the in-Delta pumps due to decreased channel flow volumes.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Soil Salinity	Elevated levels of soil salinity occur in the south and west Delta due to the poor quality of channel seepage and of applied water caused by ocean salinity intrusion and high total dissolved solids concentrations from land-derived agricultural drainage.	Elevated levels of soil salinity could worsen in the south and west Delta due to the seepage and the poor quality of applied water caused by increasing amounts of ocean salinity intrusion and high total dissolved solids concentrations from increasing amounts of land-derived agricultural drainage.	**All** - Source control in the San Joaquin Valley could reduce salt loads slightly in the south Delta. Improved system integrity would reduce the risk of catastrophic levee failures which could cause increased ocean salinity intrusion. Both impacts would tend to reduce risks of increased soil salinity. **1B & C.** South Delta water quality *improvement facilities* should reduce the salt loads in applied irrigation water there. **1C.** Additional surface and groundwater storage would increase the amount of water available during summer and fall to dilute land-derived salinity and repulse sea water, thus reducing applied salt loads.	**All** - Source control in the San Joaquin Valley could reduce salt loads slightly in the south Delta. Improved system integrity would reduce the risk of catastrophic levee failures which could cause increased ocean salinity intrusion. Both impacts would tend to reduce risks of increased soil salinity. **2A-D.** South Delta water quality *improvement facilities* (and to some extent the 3 South Delta Intake Structures) should reduce the salt loads in applied irrigation water there. **2B & E.** Additional surface and ground-water storage would increase the amount of water available during summer and fall to dilute land-derived salinity and repulse sea water, thus reducing applied salt loads.	**All** - Source control in the San Joaquin Valley could reduce salt loads slightly in the south Delta. Improved system integrity would reduce the risk of catastrophic levee failures which could cause increased ocean salinity intrusion. Both impacts would tend to reduce risks of increased soil salinity. **3A-D, &G.** South Delta water quality *improvement facilities* should reduce the salt loads in applied irrigation water there. **3B & 3D-I.** Additional surface and groundwater storage would increase the amount of water available during summer and fall to dilute land-derived salinity and repulse sea water, thus reducing applied salt loads.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
Soil Selenium	High Selenium concentrations can be anticipated to recur in the channels and applied irrigation water in the South Delta from land-derived San Joaquin Valley agricultural drainage.	High selenium concentrations could intensify in the channels and applied irrigation water in the South Delta from land-derived San Joaquin Valley agricultural drainage.	**All** - Essentially the same as No Action except that removal of some lands from production would tend to reduce selenium in agricultural drainage, with the amount of reduction depending on the geographic area selected for retirement.	**All** - Source control in the San Joaquin Valley could reduce selenium loads slightly in the south Delta. This impact would tend to reduce risks of increased soil selenium concentrations. **2A-D.** South Delta water quality improvement facilities (and to some extent the 3 South Delta Intake Structures) should reduce the salt loads in applied irrigation water there. **2B & E.** Additional surface and ground-water storage would increase the amount of water available during summer and fall to dilute land-derived salinity and repulse sea water, thus reducing applied salt loads.	**All** - Source control in the San Joaquin Valley could reduce selenium loads slightly in the south Delta. This impact would tend to reduce risks of increased soil selenium concentrations. **3A-D, &G.** South Delta water quality improvement facilities should reduce the Se loads in applied irrigation water there. **3B & 3D-I.** Additional surface and groundwater storage would increase the amount of water available during summer and fall to dilute land-derived salinity and repulse sea water, thus reducing applied salt loads.
Subsidence Caused by Peat Oxidation	This process occurs in Delta island interiors where peat is a	Subsidence caused by peat oxidation would continue unabated	**All** - Habitat restoration activities could potentially reduce	**All** - Same as Alternative 1.	**All** - Same as Alternative 1.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
	significant soil constituent. The rate of subsidence is proportional to the rate of oxidation, which in turn depends on the amount of oxygen available.	under the No Action Alternative, further intensifying the adverse conditions.	subsidence rates since they would restore humus and nutrients to the island soils		
Subsidence Caused by Groundwater Withdrawals	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Seismicity	High risk of soil erosion and loss due to moderate to severe earthquake potential. Potential incidents range from single, isolated failure to widespread, catastrophic levee failures.	The existing risk would be further increased and compounded by continued subsidence under the No Action Alternative.	Same as Existing since upgrading of levees to PL99 standards would tend to offset effects of continued subsidence.	**2A-D.** Channel improvements and levee setbacks would further reduce the risks. **2.E.** Further reduced risk due to additional wetland habitat restoration and levee setbacks.	**3A-I.** The Isolated Facility could relieve some of the hydrostatic pressure on Delta levees and resultant potential for soil erosion associated with seismic levee breaks. **3F.** Would provide additional benefit of using some of the most seismically vulnerable islands for transport, thus reducing overall risk.
MITIGATION STRATEGIES	N/A	N/A	**All** - Upgrading levees to PL-99 standards would mitigate to a degree.	**All** - Interiors of flooded islands would require protection against erosion with vegetation, soil matting or rock.	**All** - Interiors of flooded islands would require protection against erosion with vegetation, soil matting or rock.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
					3E. Interiors of flooded islands would require the most protection against erosion with vegetation, soil matting or rock.
Sacramento River Region					
Surface Soil Erosion	Surface soil erosion is a significant problem in Sacramento River Region watersheds, along levees, and in degraded riparian zones.	Surface soil erosion can be expected to worsen in Sacramento River Region watersheds, along levees, and in degraded riparian zones if No Action is taken.	**All** - Watershed management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **C** - Short-term increases would occur during construction of storage facilities	**All** - Watershed management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **B/E** - Short-term increases during construction of storage facilities	**All** - Watershed management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **B/D/E/F/G/H/I** - Short-term increases during construction of storage facilities
Channel Erosion and Sedimentation	Surface soil erosion is a significant problem along river banks and within channels of the Sacramento River system and its tributaries.	Surface soil erosion could continue or worsen along river banks and within channels of the Sacramento River system and its tributaries.	**All** - Re-establishment of stream meander belt on some reaches could help restore natural sediment transport and depositional processes, if properly designed. **All** - Increased potential for sediment transport and deposition associated with re-	Same as Alternative 1. **All** - Increased potential for sediment transport and deposition associated with new SWP-CVP facilities.	Same as Alternative 2.

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
			operation of SWP-CVP facilities.		
Soil Salinity	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Soil Selenium	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Subsidence Caused by Peat Oxidation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Subsidence Caused by Groundwater Withdrawals	Localized and currently stabilized	No change	No change	No change	No change
Seismicity	Risk of activity	No change	No change	No change	No change
MITIGATION STRATEGIES			Careful design of river channel and bank modifications, consistent with fluvial geomorphologic principles. Use of watershed and bank protection measures to reduce erosion. Minimize disruption of natural hydrologic regimes.	Same as Alt 1.	Same as Alt 1.
San Joaquin River Region					
Surface Soil Erosion	Surface soil erosion is a significant problem in San Joaquin River Region watersheds, along levees, and in the extensively degraded riparian zones.	Surface soil erosion can be expected to worsen in San Joaquin River Region watersheds, along levees, and in the degraded riparian zones if No Action is taken.	**All** - Watershed management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **C** - Short-term	**All** - Watershed management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **B/E** - Short-term	**All** - Watershed Management measures that are included in the Water Quality Common Program would reduce surface soil erosion potential somewhat. **B/D/E/F/G/H/I** - Short-

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
			Increases during construction of storage facilities	increases during construction of storage facilities	term increases during construction of storage facilities
Channel Erosion and Sedimentation	Surface soil erosion is a significant problem along river banks and within channels of the San Joaquin River system and its tributaries.	Surface soil erosion can be expected to continue or worsen as a significant problem along river banks and within channels of the San Joaquin River system and its tributaries.	**All** - Re-establishment of stream meander belt on some reaches could help restore natural sediment transport and depositional processes, if properly designed. **All** - Increased potential for sediment transport and deposition associated with re-operation of SWP-CVP facilities.	Same as Alternative 1. **All** - Increased potential for sediment transport and deposition associated with new or augmented storage facilities.	Same as Alternative 2.
Soil Salinity	Elevated soil salinity concentrations and mass in the southern and western portions of the valley threaten land productivity and downstream soils affected by applied and river channel water quality.	Conditions can be expected to worsen as additional salt load is imported to the valley and leached from the soils by irrigation. More agricultural soils would be degraded and/or go out of production in the more seriously affected areas.	Same as No Action impacts.	Some improvement and stabilization of conditions can be expected to the same degree that the salt loads contained in water exported to the San Joaquin Valley are reduced.	More improvement and stabilization of conditions can be expected to the same degree that the salt loads contained in water exported to the San Joaquin Valley is improved by diversion of good quality water through the Isolated Facility directly from the Sacramento River.
Soil Selenium	Elevated soil selenium concentrations and mass in the southern and western portions of	Conditions can be expected to worsen as additional salt load is imported to the valley	Same as No Action impacts.	Some improvement and stabilization of conditions can be expected to the same	More improvement and stabilization of conditions can be expected to the same

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
	the valley threaten land productivity for agricultural crops and wetland plants (needed by waterfowl) and downstream soils affected by applied and river channel water quality.	and Selenium is leached from the soils by irrigation and natural drainage from contaminated native soils on the east-side. More agricultural and wetland soils would be degraded and/or go out of production in the more seriously affected areas.		degree that selenium loads contained in water exported to the San Joaquin Valley are reduced.	degree that the selenium loads contained in water exported to the San Joaquin Valley is improved by diversion of good quality water through the Isolated Facility directly from the Sacramento River, thus avoiding the addition of ocean- and Delta-derived Selenium loads (slight, but cumulative).
Subsidence Caused by Peat Oxidation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
Subsidence Caused by Groundwater Withdrawals	Subsidence caused by groundwater withdrawals has been a continuing problem in the San Joaquin Valley as exemplified by the results of the 1987-92 drought	Subsidence caused by groundwater withdrawals can be expected to continue and worsen as groundwater pumping continues and increases to make up for surface and project water delivery shortages.	Minimal change compared to No Action Alternative. Promotion of conjunctive use practices, which are part of the Water Use Efficiency Common Program, would have the greatest potential to improve conditions.	Subsidence caused by groundwater withdrawals could be reduced as a result of development and delivery of additional water supplies to the Valley. Promotion of conjunctive use practices, which are part of the Water Use Efficiency Common Program, also would have good potential to improve conditions.	Subsidence caused by groundwater withdrawals could be reduced even more as a result of development and delivery of additional water supplies to the Valley and significant improvements to water quality. Promotion of conjunctive use practices, which are part of the Water Use Efficiency Common Program, would have greater potential to

RESOURCE CATEGORY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3
					improve conditions with the better water quality.
Seismicity	Risk of activity	No change	No change	No change	No change
MITIGATION STRATEGIES			Careful design of river channel and bank modifications, consistent with fluvial geomorphologic principles. Use of watershed and bank protection measures to reduce erosion. Minimize disruption of natural hydrologic regimes. Agricultural drainage and salt management programs such as a drain to the ocean can help mitigate high soil salinity and Selenium concentration problems.	Same as Alternative 1.	Same as Alternative 1.

A, B, C, D, E, F, G, H, I - Subalternatives
All - Applicable to all the subalternatives

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